Nuclear structure near N =108 deformed shell gap: case of ^{187}Os

S. Nandi[1,2,*] G. Mukherjee[1,2], A. Dhal[1], R. Banik[1,2], S. Bhattacharya[1,2], C. Bhattacharya[1,2], S. Bhattacharyya[1,2], S. Kundu[1,2], D. Paul[1,2], Sajad Ali[2,3],S. Rajbanshi[4], H. Pai[2], P. Ray[2,3], S. Chatterjee[5], S. Das[5], S. Samanta[5], A. Goswami[3], R. Raut[5], S. Ghugre[5], S. Biswas[6]

[1]Variable Energy Cyclotron Center, 1/AF Bidhannagar, Kolkata 700064, INDIA
[2]HBNI, Training School Complex, Anushaktinagar, Mumbai-400094, India
[3]Saha Institute of Nuclear Physics, Kolkata, 1/AF Bidhannagar, Kolkata 700064, INDIA
[4]Dum Dum Motijheel College, Kolkata, INDIA
[5]UGC DAE CSR, Kolkata700098, INDIA
[6]Grand Accélérateur National d'IonLourds,Boulevard Henri Becquerel, 14000, Caen, FRANCE
** email: s.nandi@vecc.gov.in*

Introduction

Osmium nuclei lie between the axially deformed prolate rare earth [1] and spherical Pb nuclei [2]. Many of the even–even Os isotopes are known to be γ-soft and odd-A Os isotopes show rotational bands based on different multi-quasiparticle configurations. The study of the dependence of different properties of these bands, e.g. the signature splitting, band crossing frequency, gain in alignment, etc., as a function of neutron and/or proton Fermi level is an important aspect in nuclear structure physics. The neutron Fermi levels in light Os nuclei lie in the mid-upper part of the $i_{13/2}$ orbital, so their shapes tend to take appreciable prolate deformation. However, as the Fermi level moves up to the upper part of the $i_{13/2}$ orbital, the oblate deformations are expected for the heavier ones. But the experimental data for heavier odd A Os isotopes are very scarce.

We have performed an experiment to study the high spin state of ^{187}Os and have extended its earlier established level scheme through the observation of several new bands and band crossings for the first time. The band built on $7/2^-[503]$ configuration and its band crossing phenomenon have been discussed here.

Experimental details

The excited states in heavier Os isotopes can only be populated by using light ion induced reaction or deep-inelastic scattering. In this experiment the ^{186}W(^{4}He,3n)^{187}Os reaction at 36 MeV was used. The beam was delivered from the K-130 cyclotron at VECC, Kolkata and the INGA, which at the time of the experiment comprised of 7 Compton suppressed Clover and 1 LEPS detector, was used to detect the γ-rays. A stack of 3 ^{186}W foils, each ~300μg/cm^2 thick on 20μg/cm^2 ^{12}C backing, were used as targets. The target was prepared by electron gun evaporation technique in ultra-high vacuum environment in the target lab of IUAC, New Delhi. Two and higher fold coincidence data were recorded using PIXIE-16 digitizer based system developed by UGC-DAE-CSR, Kolkata Centre [3] and the data were processed using the IUCPIX package [3] and analyzed using the RADWARE software.

Experimental results

Partial level scheme of ^{187}Os relevant to present paper is shown in Fig.1. The crossing frequency (ω_c) and the levels above it in the band based on the $7/2^-[503]$ configuration has been identified in this work. The new γ-rays of this band are evident in the 196-keV gated spectrum, shown in Fig.2. The spin and parity of the excited states were assigned from the conventional DCO and the IPDCO measurements.

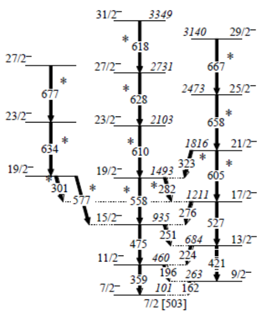

*Fig-1 Partial level scheme of ^{187}Os proposed from this work; * stands for newly observed γ-rays.*

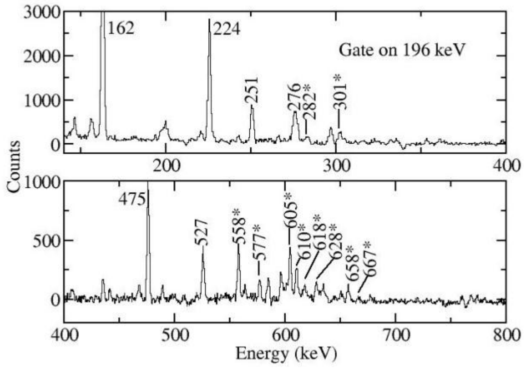

Fig. 2: Coincidence spectra gated by 196-keV in ^{187}Os

Discussions

Aligned angular momentum (i_x) vs. rotational frequency (ω) plot (Fig. 3) for the 7/2$^-$[503] band in ^{187}Os and its neighbors shows ω_c ~ 0.23 and 0.34 MeV for ^{183}Os and ^{185}Os (N = 107, 109), respectively. The delayed crossing in ^{185}Os was attributed to a deformed shell gap at N = 108 [4]. In ^{187}Os (N = 111), ω_c = 0.3 MeV is smaller than but closer to ^{185}Os. This indicates the existence of a deformed shell gap at N = 110, similar but less pronounced than the one at N = 108.

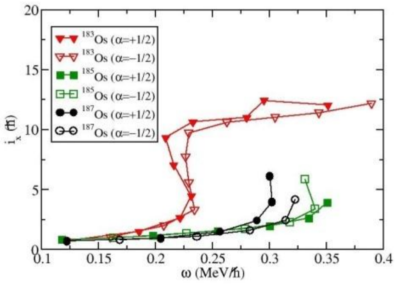

Fig. 3: i_x vs. rotational frequency (ω) plot

The energy staggering, S(I), vs. spin has been plotted in Fig. 4 for different odd-A Os and Odd-A W isotopes for the same band based on 7/2$^-$[503]. All the isotopes show very similar behavior of S(I) with no staggering at lower spin (I). However, at higher spins, they differ for the Os isotopes. ^{183}Os (N = 107) and ^{187}Os (N = 111) show similar large staggering after I = 9.5ħ but in case of ^{185}Os (N = 109), the staggering is small and in opposite phase to that of ^{183,187}Os. Data on W isotopes corresponding to the same neutron number are not known at higher spins for comparison. A change in staggering from small to large value of S(I) can be attributed to a change in shape with spin. However, this can also be explained by γ-softness as in ^{183}Os [5]. The ground state shape of ^{186}Os is calculated as γ-soft [6] and so, it may be possible that the odd-neutron in high-Ω, $h_{9/2}$ orbital in ^{187}Os, drive the γ-soft shape of the core to an oblate deformation at higher spin. Therefore, the large value of S(I) in ^{187}Os can be explained either by γ-softness or prolate to oblate shape transition. The difference in energy staggering for N = 107, 109 and 111 may, therefore, indicates different structures in Os isotopes. Detail analysis and theoretical calculations are in progress.

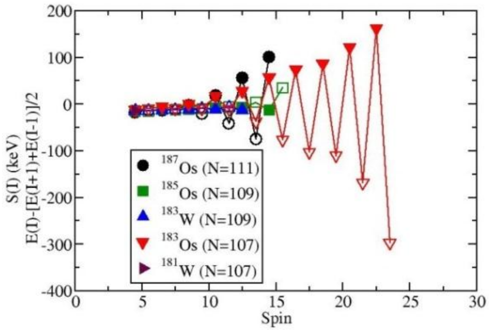

Fig. 4: Energy Staggering S(I) vs. Spin (I)

Acknowledgement

We acknowledge the cyclotron operators at VECC for good α beam and the support of K. Basu (UGC-DAE-CSR) for the up keeping of the clovers, A. Choudhury, P. Mukherjee and I. Shaik (VECC) for their help during experiment. We thank D. Kabiraj and Abhilash at IUAC, New Delhi for their help in target preparation. INGA is partially funded by DST, Govt. of India (No. IR/S2/PF-03/2003-II).

References

[1] Y. Lee et al., Phys. Rev. Lett. **38**, 1454 (1977).
[2] G. Baldsiefen et al., Nucl. Phys.A **574**,521(1994).
[3] S. Das et al., Nucl. Inst. and Meth.Phys. Res.A **893**,138 (2018).
[4] T. Shizuma et al., Phys. Rev. C **69**, 024305 (2004)
[5] T. Shizuma et al., Nucl. Phys.A **696**, 337 (2001).
[6] S. Nandi and G. Mukherjee, Proc. this symp.